



REPORT
ON
DRY LAND FARMING :
TRENDS AND PROSPECTS



GOVERNMENT OF INDIA
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F O R W O R D

It is now widely recognized that agricultural growth achieved so far, particularly in the post-green revolution period, has led to widening of regional disparities including between dry land and irrigated areas. Even after realising the entire irrigation potential in the country, about half of the area will still remain unirrigated. Therefore, development of dry land farming is important on considerations of both growth and equity. In the Seventh Five Year Plan, therefore, very high priority has been accorded to development of dry land farming.

This study entitled "Dry Land Farming: Trends and Prospects" by Dr. P.Rangaswamy presents an analysis of production trends and prospects in the light of the potential for and constraints to dry land farming. He has also come out with specific strategies for the development of dry land agriculture. This work was done by Dr. Rangaswamy as Consultant in the Perspective Planning Division of the Planning Commission.

The report is being brought out with the hope that it would evoke fruitful discussion among academic community, policy makers, administrators and the public at large on this vital area of concern.

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I

Production Trends and Prospects of Dryland Crops

Introduction

Development of dryland farming is assuming increasing importance on considerations of both growth and equity. It is well-known that the irrigation-based seed-fertiliser technology introduced in the country in the mid-sixties, helped in achieving the objective of self sufficiency in foodgrains, but the regional distribution of the benefits of the technology was not even, especially between irrigated and dry farming areas.

The production of coarse cereals, pulses and oil seeds predominantly grown on drylands has been lagging behind that of superior cereals. A good part of the area under rice (58%) and wheat (30%) is also rainfed where yields are much lower than those of irrigated areas. Thus the need to develop dryland agriculture has become urgent not merely to reduce regional imbalances but also to tap the available potential from less endowed regions.

In view of the fact that coarse grains form the staple diet of the rural poor in the vast dryland tracts in the country, stepping up their production becomes also an important component of the strategy to alleviate poverty. Acceleration of the growth rate in the production of pulses and oilseeds will help to correct nutritional imbalances. Broadening the base of agricultural growth is necessary not only to maintain an effective national food security system but also to generate more income and employment opportunities in the country. Increasing production of commodities in short

supply will help to relieve inflationary pressures which are particularly sensitive to the fall in the supply of agricultural commodities.

In view of the above consideration, the Seventh Five Year Plan lays great emphasis on increasing agricultural production in dry/rainfed arable lands. This chapter attempts to examine the trends in the growth of output and yields of dryland crops, with special reference to coarse cereals.

Growth Rates

Estimates of the compound growth rates of crop production over the period 1949-50 to 1983-84 show virtual stagnation in the production of pulses (Table 1.1). The performance of coarse cereals and oil seeds is better than that of pulses but not as good as that of the superior cereals. Among the coarse cereals, the performance of maize and bajra seems to be comparatively better over the period 1949-50 to 1983-84. But the rates of growth between 1967-68 to 1983-84 indicate that the growth of bajra and maize has considerably slackened since late sixties, while that of jowar and ragi has picked up in the latter period. Small millets and bar ley, however, showed negative rates of growth in production in both the periods. Among oilseeds, rapeseed and mustard have done better than groundnut and sesamum.

Regarding the relative contribution of area and yield of crops to their production, it is seen that while both area and yield have contributed to production in the case of wheat

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and rice, it was largely yield increase that has raised the production of jowar, bajra and ragi. In fact, the yield growth rates of the latter have been equal to or higher than that of rice. Coarse cereal production did not increase much, mainly because of the loss of area to competing crops induced by irrigation coupled with new technology and/or higher prices.

Pulses, on the whole, have not gained in respect of either area or yield, though there are inter-regional variations in this regard. This is because there has been very little technological change in respect of pulses in contrast to the case of coarse cereals. Rabi pulses especially (which account for a high share of the total pulse output) had to face stiff competition from wheat and hence lost heavily in area. Oilseeds production, on the other hand, shows relatively better performance due to yield increases and area expansion. Contribution of yield component has become important since the mid-sixties. Among oilseeds, the performance of rapeseed and mustard is better as it accounted for a much higher percentage of irrigated area than other crops.

Seasonwise change in crop production:

Changes in crop production between the triennia 1962-65 and 1981-84 indicate that kharif coarse cereals viz. kharif jowar, bajra, maize and ragi (with the exception of small millets) have done better than rabi coarse cereals viz. rabi jowar and barley (Table 1.2).

Three reasons can be given for this trend: (1) better

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Table 1.1

Compound growth rates of area, production and yield of crops in India

Crops	(Percent)					
	During 1949-50 to 1983-84			During 1967-68 to 1983-84		
	Area	Production	Yield	Area	Production	Yield
Rice	0.92	2.46	1.53	0.64	2.27	1.62
Wheat	2.80	6.02	3.12	2.68	5.77	3.00
Jowar	-0.16	1.37	1.53	-0.76	2.04	2.82
Bajra	0.34	2.13	1.79	-0.79	0.70	1.51
Maize	1.86	2.63	0.75	-0.05	0.66	0.70
Ragi	0.27	1.84	1.57	0.61	2.79	2.18
Small Millets	-0.77	-0.90	-0.13	-1.79	-1.23	0.57
Barley	-2.04	-0.80	1.27	-4.50	-3.01	1.54
Coarse cereals	0.46	1.47	1.28	-0.89	0.91	1.75
Total cereals	0.84	2.96	1.77	0.37	2.87	2.04
Gram	-0.55	Negligible	0.55	-0.35	0.51	-0.19
Tur	0.60	0.26	-0.35	0.99	1.38	0.39
Other Pulses	0.80	0.47	-0.33	0.85	0.79	-0.06
Total Pulses	0.33	0.23	0.08	0.47	0.35	-0.02
Total Food grains	0.74	2.61	1.56	0.38	2.61	1.84
Groundnut	1.42	1.98	0.55	0.02	1.23	1.20
Sesamum	0.05	0.46	0.41	-0.33	1.22	1.57
Rapeseed & Mustard	1.80	3.13	1.30	1.42	2.53	1.09
Total oilseeds	1.06	2.00	0.62	0.32	1.53	1.13

Source: India, Ministry of Agriculture and Rural Development, Directorate of Economics & Statistics, Indian Agriculture in Brief, 20th edition, 1985.

technological progress in the case of kharif coarse cereals as compared to rabi coarse cereals, (ii) greater impact of technology in kharif due to better moisture conditions than in rabi and (iii) keen competition with wheat faced by barley and rabi jowar, with the extension of irrigation.

Total pulse production increased only by 6% between the two periods, due to the loss in area (in favour of wheat and other irrigated crops) and a marginal increase in yields (though there are inter-state variations in this regard). It may be noted however, that kharif pulse production went up by as much as 34%, while rabi output went down by 7% between 1967-70 and 1981-84. Since rabi output formed a larger share of the total pulse production, the total output increased only marginally.

The total foodgrains production increased by 54.7 m.t. between the pre-green revolution period and early eighties. This was achieved largely by rise in yield (52%) and some extension in area (8%). The crops which have contributed to the additional production are wheat (30.8 m.t.), rice (16.9 m.t.), Jowar (2.0 m.t.) maize (2.5 m.t.), ragi (0.7 m.t.) and bajra (2.0 m.t.). The net contribution of coarse cereals (after allowing for reductions in the case of 47.7 m.t. by rice and wheat. As a result, their share in the total cereal output was reduced from 34% in 1962-65 to 25% in 1981-84.

Inter-State variations:

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We have given above the all India picture, but there are large inter-State variations in the growth of output of coarse cereals, pulses and oilseeds and their shares in total output. We shall confine ourselves here to an analysis of the production of coarse cereals.

The main coarse-cereals producing States are Gujarat, Karnataka, Maharashtra, Rajasthan, Andhra Pradesh, Madhya Pradesh, Tamil Nadu and Uttar Pradesh.

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Table 1.2

Increase in foodgrains production, area and yield in 1981-84 over 1962-65 - All India

Crop	Increase in production		Increase in area		Increase in yield	
	'000 t	Percent	'000 ha	Percent	Kg/ha	percent
Rice						
Kharif@	13515	38	2733	8	283	28
Summer	3356	384	1266	190	878	67
Total	16871	46	3999	11	321	32
Jowar						
Kharif	2125	35	1141	10	271	50
Rabi	-85	-3	728	10	43	9
Total	2040	21	1869	10	184	35
Bajra	1979	48	215	2	165	45
Maize	2512	55	1234	27	219	22
Ragi	697	34	19	1	268	33
Small millets	-421	-22	1017	-22	1	0
Wheat	30836	281	9865	73	977	120
Barley	-444	-19	1296	-46	408	50
Coarse cereals						
Kharif	6892	37	690	2	216	39
Rabi	-529	-9	2025	-21	83	14
Total	6363	26	2715	-6	190	34
All cereals						
Kharif	20407	37	2043	3	262	34
Rabi	33663	192	9106	38	816	112
Total	54070	75	11149	12	434	56
Pulses						
Kharif*	1145	34	1414	16	59	16
Rabi*	-542	-7	30	-23	-41	-7
Total	666	6	747	-3	44	9
Total foodgrains	54736	66	10402	9	369	52

* Increase in 1981-84 over 1967-70. @ Includes autumn and winter rice.

Source: India, Ministry of Agriculture, Directorate of Economics and Statistics, Area and production of principal crops in India, 1981-84.

They produced about 87 per cent of the total coarse cereal output during 1962-65. Of these, the first four States contributed 44% of the total output. The share of coarse cereals in the total cereal production of each of these four states (which may be called Group A States) was more than 60% during 1962-65, and in the other four States (which may be called Group B States), it varied from 29% to 37%. (See Table 1.3).

The contribution of Group A States to all India output of coarse cereals rose from 44% to 51%, while that of Group B states fell from 43% to 35% between early sixties and eighties.

The share of coarse cereals in the total cereal output has, in general, fallen in these States over time, with the exception of Karnataka. The fall is steep in the case of Group B States.

The coarse cereal production increased in all the four States in Group A and only 2 out of the four States in Group B, between 1962-65 and 1981-84. The percentage increases were also higher in Group A States than in Group B States.

It may be noted that increase in the production of coarse cereals has come about largely through rise in yields. Area under coarse cereals has fallen in 5 out of 8 States. Area has increased only in the States of Maharashtra, Rajasthan and M.P.* where the percentage of total irrigated area to gross cropped area is low and where the yields are also lower or have not increased much over time. This implies a shift ~~off~~ area under coarse cereals from the high yield regions to the low yield areas. This is true not only of interstate shifts but also intra-state shifts. This is another major constraint to the increase of coarse cereals production which calls for

* These are the only States where pulse area also has increased.
See Chopra (1982).

Table 1.3
Change in coarse cereals output, area and yield between 1962-65 and 1981-84
(triennial averages)

States	State's share (%) in the all India coarse cereals output		Share of coarse cereals (%) in total cereal out. put of each state		Changes in coarse cereals		
	1962-65	1981-84	1962-65	1981-84	Output 000t	Area percent 000/ha	Yield percent kg/ha per cent
Group A							
Gujarat	6.7	8.1	67	54	855	52	13 373 75
Karnataka	10.6	12.6	61	62	1301	50	13 369 72
Maharashtra	16.4	19.1	69	67	1863	46	6 183 39
Rajasthan	10.6	11.0	70	49	776	30	6 87 23
Total:	44.3	50.8	67	59	4795	44	1 211 45
Group B							
Andhra Pradesh	10.3	9.0	36	26	271	11	-22 220 41
Madhya Pradesh	10.7	10.5	34	30	606	23	10 75 12
Tamil Nadu	6.5	4.6	29	24	-173	-11	-24 139 18
Uttar Pradesh	15.4	11.0	37	14	-396	-10	-27 165 23
Total:	42.9	35.1	34	21	308	3	-16 141 22
All India	100.0	100.0	34	25	6363	26	6 190 34

Source: As for Table 2.

concerted efforts to improve the productivity of land resource in those regions. So far as yield increases are concerned, they were higher in Karnataka and Gujarat (more than 70%), followed by Maharashtra and Andhra Pradesh (around 40%).

Factors associated with the change in yields of coarse cereals

Now we may try to identify some of the basic factors associated with the changes in yields of the major coarse cereal crops in the States. Tables 1.4 and 1.5 show the impact of irrigation and HYV area on the yields of jowar, bajra and maize.

Jowar:

The major jowar growing States are Maharashtra, Karnataka, Madhya Pradesh and Andhra Pradesh, of which Maharashtra alone produced 41% of all India total during 1981-84. The yield levels of jowar during 1981-84 were high in Karnataka and M.P (810 kg/ha) followed by Maharashtra and Tamil Nadu (720 kg/ha). These are associated with relatively higher levels of HYV coverage, even though irrigated area under jowar constituted only around 5% or less, except in Tamil Nadu.

Yield levels are low in Rajasthan, Gujarat and Andhra Pradesh due to low levels of HYV coverage. Low moisture conditions in large areas of these States as well as

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susceptibility of the hybrid varieties to pests and diseases could have been deterrent factors in their diffusion. This calls for development of HYVs resistant to droughts and pests besides enhancing the moisture availability through water-harvesting and other means.

Percentage increases in yield between early sixties and eighties have been higher in Group A States than those of Group B, partly due to the lower base level yields of the former and this has narrowed down the yield gaps between the two groups of States.

Bajra:

The major bajra producing states are Gujarat, Rajasthan, U.P, Maharashtra, Tamil Nadu and Haryana. Gujarat and Rajasthan alone produced 44% of the total output of bajra during 1981-84. Gujarat and Tamil Nadu had the highest yields (more than 950 kg/ha) during 1981-84. They have much higher coverage under HYV than the other states and also relatively higher levels of irrigation. In sharp contrast to Gujarat, the other important bajra-growing state, Rajasthan has a low coverage of HYV and the lowest yield (314 kg/ha). Even though the percent of HYV area is less in U.P and M.P, they have higher yields due to assured rainfall conditions. One can very well imagine the potential for higher yields in these states if substantial area can be brought under hybrids. But bajra hybrids as in the case of jowar, are susceptible to diseases like downy mildew

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Tabl 1.4

Impact of irrigation and HYV area on yields of
jowar and bajra

States	Average for 1981-84		Yield (kg/ha)	Increase in 1981-84 over 1962-65		
	% of irri- gated area to total area under Jowar/Bajra*	% of area to crop area		In irriga- ted area (percentage points)	In yield (kg/ha)% in crease	
1	2	3	4	5	6	7

JOWAR

Group A

1. Gujarat	3.3	10.3	571	-0.9	263	85.4
2. Karnataka	4.7	23.9	808	2.6	329	68.7
3. Maharashtra	4.9	37.5	720	-0.1	186	34.8
4. Rajasthan	1.7	3.7	465	-0.7	144	44.9

Group B

5. Andhra Pradesh	0.9	19.8	626	0	119	23.5
6. Madhya Pradesh	0.1	34.6	815	0.1	72	8.8
7. Tamil Nadu	14.2	33.3	725	-4.5	-36	-4.7
8. Uttar Pradesh	0.7	0.4	737	-0.3	107	17.0
All India	3.8	27.5	706	-0.1	184	35.2

BAJRA

Group A

1. Gujarat	9.4	85.5	997	6.3	489	96.3
2. Karnataka	4.8	42.8	458	4.4	194	73.5
3. Maharashtra	2.5	51.2	423	0.5	129	43.9
4. Rajasthan	3.9	26.2	314	3.6	87	38.3

Group B

5. Andhra Pradesh	11.2	62.6	687	0	99	19.1
6. Madhya Pradesh	-	23.0	592	-	-128	-17.8
7. Tamil Nadu	13.3	79.0	953	2.0	299	45.7
8. Uttar Pradesh	2.5	12.9	769	2.3	176	29.7
9. Haryana	13.5	61.7	629		266	73.3
All India	5.9	42.6	528	3.0	164	45.1

- negligible

* 1981-82

and ergot which are aggravated under high moisture conditions. Unless varieties resistant to such diseases are evolved in the Research Stations, there is not much scope for the spread of these hybrids.² 8-1801 *

Yields have risen in all the States except M.P. The percentage rise in yield has been high in Gujarat, followed by Karnataka and Haryana, though the base level yields have been lower in the latter. The HYV adoption in the case of bajra seems to be better than that of jowar. There has also been some increase in irrigated area under bajra in 5 States, in contrast to the case of jowar.

There is scope to raise bajra yields, by co-ordinated efforts to bring more area under the hybrids particularly in the low yield States and also by removing constraints to their diffusion, through development of drought- and disease-resistant HYVs. Bajra yields are also subject to greater fluctuations than jowar, possibly because it is grown under conditions of low rainfall and also because the areas of low rainfall are characterised by high variability of (high coefficient of variation). There is glut in its production in good rainfall years and fall in drought years. These cause high fluctuations in its prices. Incentives like support prices to the farmer as well as efficient distribution of good quality seeds and other inputs are essential for the diffusion of hybrid technology.

/ rain
fall

2. Some progress in this direction has been made recently..

Table 1.5
The impact of irrigation and HYV area on the
yield of Maize

States	Average of 1981-84		Yield (kg/ha)	Increase in 1981-84 over 1962-65		
	% of irri. area to total area under Maize**	% of HYV area to crop area		In % of irri. area to crop area	In Yield kg/ha	% incre ase
1	2	3	4	5	6	7
Group A						
1. Gujarat	6.4	33.5	1254	2.8	57	4.8
2. Karnataka	81.6	100.0	2552	-18.4	1799	238.9
3. Maharashtra	9.4	71.7	1530	-32.9	863	129.4
4. Rajasthan	16.9	3.3	980	5.1	-55	-5.3
Group B*						
5. Andhra Pradesh	20.5	39.4	1882	4.9	935	98.7
6. Madhya Pradesh	0.9	22.9	1125	0.7	21	1.9
7. Uttar Pradesh	20.0	4.0	863	12.0	50	6.2
8. Bihar	25.9	63.5	1081	25.1	104	10.6
9. Himachal Pradesh	7.0	28.2	1663	1.1 ⁺	294	21.5
10. Jammu & Kashmir	5.7	17.0	1394	-3.5	518	59.1
11. Punjab	67.3	38.9	1815	22.6	540	42.4
12. Haryana	23.0	37.0	1080	-12.1 ⁺	67	6.6
13. Orissa	2.6	40.9	1066	-2.7 [£]	402	60.5
All India	19.4	29.8	1218	7.8	219	21.9

* Other important maize growing States have been added to the list.

@ Increase in percentage points between 1962-63 and 1981-82.

+ Over 1969-70

£ Over 1955-56

** 1981-82.

Maize

Important maize growing states are Bihar, U.P., Punjab, Rajasthan, M.P. (each contributing 10 to 15% of all India output). Maize, ragi and barley are crops which give better yields than other coarse cereals. This is partly because the former three crops account for a higher percent of irrigated area.

During 1981-84, Karnataka had achieved a remarkable yield of 2552 kg/ha from a base level yield of 753 kg/ha in 1962-65. This appears to be the result of 100% coverage of hybrid maize plus 82% of the area under irrigation. The hybrids have also made good progress in Maharashtra covering 72% of the area.

Bihar's yield is not commensurate with the levels of HYV and irrigation coverage, when we compare them with the average of all India and other States like Andhra Pradesh and Himachal Pradesh. In U.P., Rajasthan and Orissa, yields are low because of very low coverage under HYVs and/or irrigation.

Thus maize presents a varied picture in the different States. The impact of the hybrids and irrigation is not uniform on the yields. It appears that some environmental problems concerning soils, water-logging, pests etc. in some States could have adversely affected maize yields. Between the sixties and eighties, yields have increased by 13 and 9 q/ha in Karnataka and Maharashtra, primarily through HYVs and in spite of drastic reductions in the irrigation percentage

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Increases in yields have, however, been nominal in Gujarat, Haryana, M.P and U.P and negative in Rajasthan, the last three of which are among the major maize growing States.

Barley

Barley yields have risen by 24% to 55% in Rajasthan, Haryana and Uttar Pradesh, where more than 45% of the crop area has been covered by irrigation. Among coarse cereals, it has the highest percent (48%) of area irrigated. It has, however, lost heavily in terms of area to wheat and other rabi crops due to its lower relative yields and profitability. Consequently, its total production declined by 19% in spite of an yield increase of 50%.

During 1981-84, barley yield level was highest in Punjab (17 q/ha) where 75% of the area under barley was irrigated. It was also high in Haryana and Rajasthan (14 q/ha) with 60% of area under irrigation. On the other hand the yield was just 7 q/ha in Bihar where the percentage of area under barley irrigated was only 12.

Ragi:

The all India average yield of ragi went up by 2.6 q/ha representing 33% increase in 1981-84 over the level in 1962-65. Karnataka which produced about half of the nation's output of ragi recorded an increase of 3.7 q/ha, while Tamil Nadu got the maximum increase of 4.4 q/ha. Increase in irrigated area under ragi has been mainly responsible for this rise in yield.

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Table 1.6
Increase in the yields of some coarse cereal
crops between 1962-65 and 1981-84

<u>States</u>	(kg/ha)		
	<u>Ragi</u>	<u>Small millets</u>	<u>Barley</u>
<u>Group A</u>			
1. Gujarat	@	-152(19.4)	@
2. Karnataka	373(46.5)	46(13.7)	@
3. Maharashtra	265(35.7)	76(19.6)	@
4. Rajasthan	@	@	307(28.4)
<u>Group B</u>			
5. Andhra Pradesh	177(20.7)	50(12.2)	@
6. Madhya Pradesh	@	19(8.8)	184(23.7)
7. Tamil Nadu	439(43.7)	-6(-08)	@
8. Uttar Pradesh	186(23.4)	124(23.8)	453(55.2)
9. Orissa	184(28.9)	-19(-2.9)	
10. Bihar	39(7.0)	-55(-12.0)	138(24.9)
11. Haryana	@	@	261(23.6)
12. Punjab	@	@	437(34.3)
All India	264(32.8)	@	411(49.8)

@ = negligible area.

Source: as for Table 2

Figures in parentheses are percentage changes.

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Small millets:

The all India average yield of small millets has stagnated at about 4 q/ha between 1962-65 and 1981-84. The yield of small millets, however, has increased in the States of U.P., Maharashtra, Andhra Pradesh and Karnataka. Among coarse cereal crops, the yield of small millets and also bajra are relatively lower since they are largely grown in areas of low rainfall and/or on soils of poor fertility.

Summary and conclusions:

The main cause for the slower growth in the production of dryland crops compared to wheat and paddy appears to be technological lag and the consequent loss of area to the more remunerative crops. The extension and input supply lags may also be partly responsible for this, since the institutional infrastructure is largely concentrated in irrigated areas. By and large, production increase on dry lands (mainly coarse cereals and oilseeds) has come about via yield increase. The growth rates in the yields of some coarse cereals (jowar, bajra and ragi) compare favourably with that of rice. This suggests some technological impact on the former, even in a situation of shifts of better quality lands to the more profitable crops. Pulses, however, have lost both in respect of area and yield because of absence of improvements in technology.

There are better prospects for increasing the production of kharif coarse cereals and pulses than the

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rabi ones, due to the better moisture conditions in kharif season as well as to the competition from wheat in rabi season.

There are large inter-state variations in the growth of production of coarse cereals. Their production has increased between the early sixties and eighties in Gujarat, Karnataka, Maharashtra and Rajasthan (coarse cereal production accounted for more than or around 50% of the total cereal output in each of these States), as well as Andhra Pradesh and Madhya Pradesh. The production has declined in Tamil Nadu and Uttar Pradesh. Production increases have come about largely through yield increase. Area under coarse cereals have fallen in 5 out of the 8 States, the exceptions being Rajasthan, Maharashtra and Madhya Pradesh, Gujarat, Karnataka, and Andhra Pradesh have made good progress in raising the yields of coarse cereals (by 40% to 75%).

During 1981-84, the yields of jowar were high in Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu and these were associated with relatively higher levels of HYV coverage. Yield rates have increased more in the low-yield States, resulting in a narrowing down of the inter-state yield gaps. The yield of bajra have also gone up in most of the States in response to the increase in HYV area as well as irrigation. The progress of HYV adoption is better in the case of bajra as compared to jowar. The yields are

still low in several States like Rajasthan, Karnataka and Maharashtra due to low moisture availability as well as the incidence of pests.

Yields of maize have increased significantly in Karnataka, Maharashtra and Andhra Pradesh and also in Jammu & Kashmir, Punjab and Orissa. These gains have, however, been partly off-set by yield decline or stagnation in the major maize-growing States like Rajasthan, M.P., and U.P.

Barley yields have gone up by 24% to 55% in Punjab, Rajasthan, Haryana and U.P. where more than 45% of the crop area has been covered by irrigation. Karnataka and Tamil Nadu have raised ragi yields by about 4q/ha by extension of irrigation and possibly also through improved varieties.

The above analysis points to the need for concerted efforts to strengthen research in all the dryland crops. There is acute need for developing disease- and drought-tolerant HYVs adapted to the agroclimatic conditions of each region. At the same time, efforts should be stepped up to spread the available technology developed by All India Coordinated Research Project for Dryland Agriculture, the International Crops Research Institute for the Semi-arid Tropics and other centres for the benefit of larger areas. This requires strengthening of extension and input supply systems in the dryland regions. Investments in minor irrigation works like wells and tanks will help in the spread of available HYVs for these crops as they are highly responsive to water, the requirements of which per unit of output are low.

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II

DRYLAND FARMING POTENTIAL AND CONSTRAINTS

The production of foodgrains in India has gone up by nearly three times between 1950-51 and 1983-84. The per capita output of foodgrains rose sharply from an average of 156 kg. per annum during 1951-53 to 181 kg. during 1961-63 and thereafter increased slowly to 191 kg during 1982-84 (see table 2.1). The crops that account for the slow trend since the sixties are rice, coarse cereals and pulses. While the per capita output of wheat has been steadily going up since 1951-53 and has trebled by 1982-84, that of pulses has been steadily declining from the early 50's and that of rice and coarse cereals, since the early 60's. Thus the share of pulses in total foodgrains output has gone down leading to nutritional imbalances. Our oil seeds production also is not sufficient to meet the domestic demand and every year, we are spending considerable amount of foreign exchange on imports of oil seeds and oils.

Table 2.1 Per capita output of foodgrains in India
(kg per annum)

Years	Rice	Wheat	Coarse cereals	Total cereals	Pulse	Total food grains
1951-53	62.2 (40.0)	18.8 (12.1)	49.1 (31.6)	130.1 (83.7)	25.4 (16.3)	155.5 (100.0)
1961-63	76.3 (42.2)	25.0 (13.8)	52.8 (29.2)	154.2 (85.3)	26.6 (14.7)	180.7 (100.0)
1971-73	73.4 (40.1)	44.3 (24.1)	46.4 (25.2)	164.3 (89.4)	19.4 (10.6)	183.8 (100.0)
1982-84	73.4 (38.6)	57.7 (30.3)	42.8 (22.5)	174.2 (91.4)	16.5 (8.7)	190.6 (100.0)

Note: Figures in parentheses are percentages to total foodgrains.

Source: India, Ministry of Agriculture, Bulletin on Food Statistics, 1980 and 1982-84 Issues.

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It is well known that the coarse cereals form the staple diet of the rural poor in the areas where they are grown- primarily dry farming areas in Maharashtra, Gujarat, Karnataka, Andhra Pradesh, Madhya Pradesh, Rajasthan, Tamil Nadu, Himachal Pradesh and Jammu & Kashmir. A disturbing trend is that the ~~prices~~ prices of these crops relative to that of wheat or paddy have been, in general, increasing over time, which is a sign of supply constraints, contrary to the popular notion of demand constraints in respect of coarse cereals (see Table 2.2. It is generally asserted that coarse cereals being inferior goods, have negative or low income elasticities of demand, and their price elasticities of demand are also low. Indeed, some estimates made by FAO and NCAER show negative income elasticities of demand but other estimates made by Bapna, Murthy and Lalitha, Narayanan and Rao etc. show positive and fairly high figures, at least in the rural areas and for the low income groups who form the majority of the population.¹ So their demand for coarse cereals will go up with the increase in income or fall in the prices.

N.S.S. data on per capita consumption of cereals in rural areas during 1961-62, 1964-65, 1973-74 and 1977-78 (Table 2.3 show that the consumption of wheat has been continuously increasing, while that of bajra increased till 1973-74 and thereafter declined sharply in 1977-78. On the other hand, the consumption of rice and jowar

¹ see foot note on p. 24.

Table 2.2

Ratios of the consumer prices of coarse cereals
to those of wheat and rice in rural areas, India.

(per cent)

Coarse Cereals	1961-62		1964-65		1973-74		1977-78	
	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice
Jowar	81	66	88	75	91	70	85	62
Bajra	87	71	91	78	82	63	91	67
Other Coarse Cereals	79	64	85	73	86	66	86	63
Rice	123	-	117	-	130	-	136	-

Note: Prices are derived by dividing per capita
monthly expenditure on cereals by the
corresponding quantities.

Source: Calculated from P.S.George, The Changing patterns
of consumer demand for foodgrains in India, Indian
journal of Agri.Econ.35(1), 1980 and
National Sample Survey, 32nd round: July, 1977-
July, 1978.

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has fallen between 1961-62 and 1973-74 and then increased slightly, while that of other coarse cereals has been continuously decreasing. It may be noted that, except for wheat, the consumption of all other cereals has gone down in 1977-78 compared to 1961-62 levels. These changes are, generally, in line with the movements of relative prices given in Table 2.2. They reinforce the hypothesis of supply constraints in respect of coarse cereals and of rice among the superior cereals.

1 FAO(1971) estimated in income elasticity of -0.17 based on NSS data for India, while NCAER (1962) estimated elasticities of -0.29 and -0.53 for rural and urban areas respectively. Murthy and Lalitha (1983), using NSS data, arrived at positive and fairly high income elasticities; 1.035 for jowar, 0.703 for other coarse cereals and 1.016 for pulses for rural low income consumer group. The corresponding price elasticities of demand are -1.939, -1.317 and -0.911 respectively. The estimates of expenditure elasticities for jowar, ragi and barley, made by Narayanan and Rao(1982) are also high and positive for the rural low income groups in several states. Bapna(1976) says, "The NSS data of 1960-61, the NCAER data of 1959 and NLN study of 1975 exhibit that more than two-thirds of the people belong to the income category of increasing consumption and account for two-third to four-fifth of total cereal consumption".

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Table 2.3 Per capita monthly consumption of cereals in rural areas-1961-62 to 1977-78(kg)

Cereals	Bottom quartile				Top quartile				All Consumers			
	61-62	64-65	73-74	77-78	61-62	64-65	73-74	77-78	61-62	64-65	73-74	77-78
Rice	5.62	5.82	4.93	4.88	11.48	10.23	8.87	8.54	8.77	8.13	6.90	7.10
Wheat	1.11	1.33	1.76	2.17	5.99	5.58	6.54	6.77	2.64	2.74	3.52	4.00
Jowar	2.01	1.74	1.75	2.20	2.03	1.89	1.35	1.28	1.93	1.83	1.62	1.74
Bajra	0.51	0.56	0.83	0.44	1.16	1.80	1.54	1.51	0.82	1.06	1.18	0.75
Other Cereals	1.94	2.39	2.04	1.76	3.53	2.52	2.00	1.46	3.47	2.41	1.87	1.59
Total Cereals	11.19	11.34	11.31	11.45	24.19	22.02	20.30	19.56	17.53	16.19	15.09	15.25
Share of coarse cereals in total cereals(%)	39.9	39.6	40.8	38.4	27.8	28.2	24.2	21.7	34.9	32.8	30.9	26.8

Source: Same as for Table 2.2 based on N.S.S. Data.

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Constraints in Dryland Farming

1. Technological constraints:

As the earlier chapter reveals, the foremost among the several constraints responsible for the slow growth of dryland crops appear to be technological lags coupled with extension and input supply lags even in respect of the available technology.

Dryland research in this country, even though started in the early thirties, has yet to make a dent on overall productivity of the rainfed crops. There have been, no doubt, some increases in the yields of certain crops as noted earlier and in fact, the yield growth rates of several coarse cereals have been higher than that of rice. The common problem faced by rice (58% of its area is still rainfed) as well as the dryland crops is their highly heterogeneous environment in terms of soils and climate and all the aberrations associated with monsoon conditions. This is partly responsible for the limited impact of the available technology and it also indicates that evolving a better technology for these crops is complicated and difficult. The difference between rice and the dryland crops is that, with the extension of irrigation, the former has gained in area via both crop substitution and increase in cropping intensity, as it is a water-responsive high-value crop, while the latter has lost substantial area, so that yield increases have not been sufficient to raise production.

Early research in dry farming put its emphasis on soil and moisture conservation practices, particularly

contour bunding which did not make much of an impact on dryland production, in the absence of significant improvements in the plant material. There is no doubt that soil conservation is an important programme designed to solve the problem of soil erosion which is a common feature of drylands. But since its impact on production was limited and also not immediate, but distributed over time, dryland farmers, with their poor resource base, were not able to step up investment and effort.

The HYV programme initiated in the country during the mid-sixties supplied the missing biological component viz. HYVs and hybrids at least for a few coarse cereals like jowar, bajra and maize, which were adopted on a nationwide scale, though to a smaller extent compared to wheat and paddy. For other coarse cereals and almost all the pulses and oilseeds, there have been no major technological improvements.

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) started in 24 centres all over the country during the Fourth Plan period, has developed HYV based packages of practices for several dryland crops which are presumably adapted to the agroclimatic regions around each centre. These practices have made some visible impact in the project areas, as indicated by some studies. We do not have, however, information about their impact outside the project areas except for the adoption of HYVs for jowar, bajra and maize as mentioned above.

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The key elements of the technology developed in the above research centres (like Hyderabad, Bangalore, Kovilpatti, Akola, Indore, Hissar etc.) include the following:

1. Efficient crop pattern, crop rotation and inter-cropping systems tailored to the agro-climatic conditions of the region.
2. Contingency planning of alternative crops and varieties for normal and delayed monsoons.
3. Off season tillage to increase infiltration of rain water and reduce runoff.
4. Early maturing HYVs, hybrids or improved varieties which make efficient use of the available rainfall and stored soil moisture.
5. Early sowing of kharif crops to obtain vigorous seedlings and avoid incidence of pests and diseases (like shoot-fly on sorghum and downey mildew on bajra).
6. Maintaining optimum plant population, inter- and intra-row spacing, through suitable seed rates, line sowing, thinning and gap filling.
7. Timely weeding by manual, mechanical or chemical methods.
8. (a) Balanced use of N, P and K fertilisers,
(b) basal application of P and K and split application of N in kharif; basal application of N, P and K in rabi.
(c) placement or deep drilling of fertiliser in the moisture zone of the soil.

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9. Pest control and pest avoidance.
10. Basic practices of soil and moisture conservation like land levelling, smoothing, graded bunds, harrowing, recycling of run-off water, etc.
11. Use of improved implements like bullock-drawn seed-cum-fertiliser drills, dryland weeder, ridger-seeder, blade-narrow, etc.

It may be observed that many of these practices esp. HYVs, fertiliser and improved cultural practices positively interact with each other, so that each one of them is more profitable in a package than in isolation.

It appears that a judicious combination of the above practices, if adopted by dryland farmers on a wide scale (which requires the provision of necessary infrastructural and other support), can possibly help in achieving a breakthrough in dry farming. The adoption studies conducted under the Agro-economic Research Scheme of AICRPDA in 16 centres, covered only 4 practices viz., HYVs, fertiliser, application, use of pesticides and weeding. Unfortunately, we do not have information on the extent of adoption of other practices. These studies reveal that the adoption rates (in terms of the percent of farmers adopting a new practice for a particular crop) are quite high with regard to inter-culture and weeding, possibly because it is a labour-intensive practice bringing good returns and also it

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has already been to a large extent followed by farmers (See Table 4). The adoption rates are fairly high for improved seeds in respect of several crops because they are profitable. The adoption rates for the other two practices viz., fertiliser and plant protection are comparatively lower. Though these two inputs are quite profitable in good or normal years, they require relatively higher investment which is risky in view of the uncertain weather conditions. In a drought year, the whole investment may turn into loss.

The above points are illustrated with experimental evidence for bajra at Hissar centre (Table 2.5). All the three inputs, viz new variety, fertiliser and improved cultural practices were found to be profitable during the good year 1978-79, but in the drought year 1979-80, only the new variety was profitable, while the fertiliser application resulted in loss. On average for the two seasons however, the combination of the three inputs gave higher profits than the use of one or two inputs only. The profits could be more by avoiding fertiliser application in a drought season.

The results given in table 5 also indicate the higher responsiveness of hybrid bajra (BJ-104) to fertiliser and improved cultural practices. The positive interaction among the three inputs makes the package more profitable than individual inputs adopted in isolation. This possibly explains the fairly close correlation between the adoption rates for the three practices. (See Table 2.4).

Table 2.4

Rates of adoption of improved dryland practices
in Project Areas(1976-80)

Crop	Centre	Percent of adopters			
		Improved seed	Fertiliser	Plan protection	Inter-culture & weeding.
1	2	3	4	5	6
Khariif	Anantapur	0	1	5	100
Jowar	Rajkot	1	22	3	97
	Kovilpatti	100	79	47	-
	Hyderabad	11	19	17	97
	Akola	31	29	37	86
	Bellary	41	8	29	-
	All centres	22	25	25	86
Rabi	Rahuri	95	79	50	93
Jowar	Bijapur	62	14	25	100
	Solapur	92	20	12	95
	Bellary	65	28	0	-
	All centres	87	41	27	95
Bajra	Anantapur	18	13	6	100
	Hissar	42	29	14	77
	Bijapur	45	9	25	100
	Solapur	85	25	13	95
	Rajkot	72	37	2	94
	Kovilpatti	1	7	1	-
	Nagpur	12	8	-	-
	Varanasi	33	29	-	24
	Jodhpur	77	77	0	100
	All centres	48	28	8	83
Maize	Ranchi	17	4	5	94
Ragi	Bangalore	62	69	8	-
Setaria	Anant	7	4	3	5

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1	2	3	4	5	6
Upland	Bangalore	66	69	8	-
Paddy	Ranchi	3	5	2	97
	Varanasi	76	35	10	56
	All centres	57	31	7	62
Wheat	Hissar	73	60	2	73
	Indore	31	55	-	
	Ranchi	32	3	0	100
Wheat	Varanasi	73	49	30	26
	Jodhpur	77	94	-	100
	All centres	68	59	23	40
Gram	Varanasi	73	40	24	35
	Hissar	14	8	2	19
Ground nut	Anantpur	31	44	19	100
	Solapur	39	6	2	96
	Rajkot	100	72	31	94
	All centres	66	49	20	96
Castor	Anantapur	59	21	31	24
	Hyderabad	57	24	14	99
	All centres	58	23	17	88
Cotton	Hissar	49	57	52	100
	Bijapur	75	9	20	100
	Rajkot	100	60	52	93
	Akola	21	28	19	-
	Kovi;patti	6	9	-	-
	All centres	54	38	38	96

- Information not available.

Source: B.K.Rastogi and V.Annamalai, A study on the adoption and diffusion of recommended technology in dryland areas, AICRPDA, Hyderabad, 1981.

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Table 2.5: Contribution of modern inputs to yield and net return from Bajra, AICRPDA, Hissar, 1978-80

Inputs	1978-79		1979-80		Average	
	Local	BJ-104	Local	BJ-104	Local	BJ-104
	Yield (Kg/ha)					
Variety	1120	2020	1230	1760	1180	1890
Variety + fertiliser	1510	2620	1220	1740	1370	2180
Variety+Impr. Cultu.Prac	1440	2400	1300	1880	1375	2140
Vari+Ferti.+Impr. Cultu.Prac	1770	3150	1200	2050	1490	2600
	Net return (Rs./ha)					
Variety	1222	2187	1343	1901	1283	2045
Variety+Fertili ser	1261	2457	942	1489	1102	1974
Vari.+Impr.Cultu. Prac.	1474	2505	1320	1933	1398	2220
Vari+ferti.+ impr.cultu.prac	1447	2940	820	1730	1134	2336

Sources: 1. Adapted from P.Rangaswamy, 'Improved Technology for Coarse Grains: Some Constraints,' Indian J.Ag.Ec., Vol.37, No.3, 1982, p.366.

2. AICRPDA, Haryana Agricultural University, Progress Reports, 1978-80, Hissar.

Table 2.6: Average yields and return on demonstration and control farms, Bajra & Jowar, IDADP, Kovilpatti.

	Bajra (average 1976-79)			Jowar (average 1977-79)		
	Demons- tration	Control	Difference	Demons tration	Control	Difference
Grain yield (Kg/ha)	1167	577	590	1704	777	927
Gross return (Rs./ha)*	1134	628	507	1858	1018	840
Cost of produce (Rs./ha)	1128	645	483	1198	813	385
Net return (Rs./ha)	6	-17	23	660	205	455
Net return per 100 rupees invested	0.5	-2.6	4.8	55.1	25.2	118.2

* Includes the value of straw also.

Source:- 1. Rangaswamy op.cit.

2. AICRPDA, Tamil Nadu Agriculture University, Economic Analysis of New Farming Practices 1977-78 and 1978-79, Coimbatore.

The differential rates of adoption for various crops are largely explained by the profitability of the new technology for the respective crops. For instance, as the results of field demonstrations at Kovilpatti show (see Table 2.6), the new technology has been found to be quite profitable in the case of Jowar but it is hardly profitable for bajra. These results explain the very high adoption rates for jowar and very low adoption for bajra at Kovilpatti. HYV, is the basic input and once that is available and adopted, other complementary practices follow it. Such HYVs seem to be available for crops like rabi jowar, ragi, bajra, wheat, upland paddy, groundnut, cotton and castor in some centres. Adoption rates for these crops are above 50%. On the other hand, there seem to be some problems including the incidence of pests with regard to HYVs for crops like kharif jowar, setaria, maize and gram and hence their adoption rates are low. With regard to gram, the basic constraint is low moisture availability since it is raised on stored moisture in kharif-fallow lands, during rabi season. The adoption figures pertain to dry farming project areas where intensive extension work has taken place and so extension may not be a constraint. The above inferences are based on average figures for several centres. However, there are wide differences in the rates of HYV adoption between centres. For instance, with regard to kharif jowar, the HYVs have been highly

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successful in Kovilpatti with almost 100% adoption and fairly successful in Bellary also (with 41% adoption) but its adoption rate is nearly zero in Anantpur and Rajkot and only 11% in Hyderabad. Adoption of hybrids or other improved seeds for bajra is high in Solapur (85%), Jodhpur (77%) and Rajkot (72%), but it is less than 20% in Kovilpatti, Nagaur and Anantpur. Adoption of groundnut HYVs is 100% in Rajkot, but only 31% in Anantpur. For gram, the adoption is high in the high rainfed Varanasi area, but it is poor in the moisture deficit Hissar region. Differences in diffusion rates are observed with regard to other crops also. This only shows that the seed-based technology is very much location-or regions-specific and its adaptability to the particular agro-climatic environment of the region determines to a large extent, its economic viability and adoption.

It appears that the improved dry farming technology available for a few crops has been more widely adopted in the heavy black soil areas than in the shallow red soil areas. This is because of the higher fertility and moisture retention capacity of the former and the positive interaction between modern inputs and the moisture levels. HYVs and fertiliser normally require more moisture than the traditional inputs. Even the improved cultural practices aiming at better moisture conservation are observed to be profitable only when a minimum level of moisture is available for conservation.

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For instance, the adoption rates for HYVs of kharif jowar are relatively higher in the black soil areas of Kovilpatti, Akola and Bellary, the first two of which have also medium rainfall. For rabi jowar grown in the black soil regions like Sholapur and Rahuri, the adoption rates are still higher-62% to 95%. The adoption rates are 100% for cotton and groundnut in Rajkot (with black soils), whereas in the red soil region of Anantapur, they are zero for kharif jowar, 18% for bajra, 7% for Setaria and 31% for groundnut, though it is high for castor (59%).

Among the four practices mentioned above, the most profitable seems to be the variety wherever it is widely adopted. In fact, that can be said to be the basic condition to establish the economic viability of the technology. Where the new variety is only marginally more profitable than the local variety, the technology rarely becomes viable for widespread adoption. The new variety is also fertiliser-responsive in high adoption areas so that it enhances the profitability of fertiliser application compared to its use with local varieties. Farmers use fertiliser even for the local varieties but the adoption rates as well as the fertiliser doses are much lower for them as compared to those for the new varieties. So the variety seems to be the king-pin of any technological breakthrough in dry farming as in irrigated farming. Though variety by itself may not make substantial addition to profits, it can

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make an impact in combination with other complementary inputs.

2. Moisture Deficiency and Uncertainty:

The basic constraint in dry farming areas is the general deficiency and uncertainty in the availability of moisture in terms of rainfall and irrigation. This has been one of the main factors responsible for the slow progress of the technology even in respect of those dry land crops for which HYVs are available.

Table 2.7 presents the distribution of the dry farming/rainfed areas in India, according to rainfall and irrigation and status. This distribution is based on districtwise information so, may not reflect differences in rainfall and irrigation within the districts. The areas are divided into 3 categories in terms of normal annual rainfall, viz. (i) low (less than 750 mm), (ii) medium (750 mm to 1149 mm) and (iii) high (1150 mm and above). The irrigation categories are two: (i) very low (15% or less of gross sown area irrigated) and (ii) low (16 to 30% of GSA irrigated). Dry farming areas may be defined as those with less than 1150 mm of annual rainfall and 30% or less of the area irrigated (which means roughly, an average of 15% of irrigated area, since the range is from 0 to 30%). The states with predominantly dry farming areas are Maharashtra, Karnataka, Gujarat and Rajasthan. More than three-fourths of the gross sown area (GSA) were dry farming areas in Karnataka and Maharashtra during 1978-79.

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Table 2. Distribution of dryfarming/rainfed areas in India (1978-79)
(Percentage of gross sown area in each State)

Sl. No.	State	Very low irrigation (Upto 15% of GSA)			Low irrigation (16-30% of GSA)			Total %	Gross sown area('000 ha)	Overall % of GSA irrigable	
		Low RF			Med. RF						High RF
		Upto 750 mm	Med. RF less than 750 mm	High RF 1150mm and above	Low RF	Med. RF	High RF				
1	2	3	4	5	6	7	8	9	10	11	
1.	Karnataka	39.3 (4)	3.7 (1),	3.5 (2)	22.7 (4)	21.3 (4)	1.1 (1)	91.6 (16)	11133 (19)	15.4	
2.	Maharashtra	25.7 (5)	39.4 (9)	7.3 (5)	10.3 (2)	3.2 (1)	11.5 (3)	97.4 (25)	19860 (26)	11.6	
3.	Rajasthan	40.5 (7)	4.6 (3)	-	20.4 (6)	-	-	65.5 (16)	17496 (26)	19.7	
4.	Gujarat	36.3 (6)	4.1 (1)	-	22.5 (3)	5.3 (1)	7.2 (2)	75.4 (13)	10389 (19)	18.6	
5.	Madhya Pradesh	30.0 (14)	40.7 (19)	0.6 (1)	0.6 (1)	6.8 (3)	14.1 (3)	92.2 (40)	21747 (45)	11.1	
6.	Himachal Pradesh	33.8 (5)	11.1 (1)	-	-	25.0 (2)	7.5 (1)	77.4 (9)	935 (12)	16.7	
7.	Andhra Pradesh	7.8 (1)	4.6 (1)	-	15.1 (2)	15.4 (4)	-	42.9 (8)	13121 (22)	35.8	
8.	Uttar Pradesh	-	4.0 (3)	0.9 (2)	-	14.7 (7)	0.7 (2)	20.3 (14)	24300 (56)	43.5	

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Table 27 contd.

	1	2	3	4	5	6	7	8	9	10	11
9. Haryana	-	-	-	-	-	19.7 (2)	-	-	19.7 (2)	5522 (11)	53.9
10. Tamil Nadu	-	-	-	-	0.8 (1)	-	6.6 (1)	-	7.4 (2)	7684 (15)	49.7
<u>High rainfall states</u>											
11. West Bengal	-	-	-	-	53.1 (7)	-	-	27.6 (5)	80.7 (12)	7878 (15)	19.6
12. Orissa	-	-	-	-	44.2 (7)	-	-	32.0 (4)	76.2 (11)	8275 (13)	19.2
13. Bihar	-	-	-	-	35.3 (10)	-	-	22.6 (8)	57.9 (18)	11381 (31)	32.6
14. Jammu & Kashmir	-	-	-	-	38.4 (5)	-	-	-	38.4 (5)	990 (10)	40.0
All India	12.2 (23)	10.2 (37)	13.3 (59)	7.8 (20)	7.9 (29)	6.5 (23)	7.9 (29)	57.9 (191)	175177 (390)		27.5

Note: (1) GSA- Gross Sown Area, R.P.-Rainfall.

(2) No. of districts in each region is given in parentheses

(3) States with rainfall above 1500 mm and districts with more than 30% of GSA irrigated are omitted.

Source: Calculated from Directorate of Economics and Statistics, Ministry of Agriculture.

Irrigation-wise, Karnataka is better placed than Maharashtra, while the latter is better placed in terms of rainfall. About two-thirds of the GSA constitute dry lands in Rajasthan and Gujarat. Major part of the areas has low rainfall (less than 750 mm). About 37% to 60% of the area is dry in 3 states namely, Madhya Pradesh, Himachal Pradesh and Andhra Pradesh. The first two states have medium to high rainfall. Andhra Pradesh has ^{got} better irrigation facility. So the moisture status of these three states, is higher than that of the 4 states mentioned earlier.

U.P., Haryana and Tamil Nadu are states with fairly good irrigation facility (44 to 54% of GSA irrigated) and a smaller proportion of dry farming areas- about 20% in Haryana and U.P. and 7% in Tamil Nadu. The dry farming areas in Haryana have low rainfall, while those in Tamil Nadu and U.P have medium rainfall. Finally, there are the high rainfall states, namely West Bengal, Orissa, Bihar, and Jammu and Kashmir. The first two states of this group have irrigation facility only for 20% of the GSA on the whole. More than three-fourths of the area has 30% or less of irrigation. The other two states have better irrigation facility (33 to 41%).

The moisture availability in terms of rainfall and irrigation is an important factor which determines the crop pattern, yields, adoption and impact of modern inputs. For instance, there is a close association between the proportion

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of dry farming areas to gross sown area, and that of coarse cereals area to the area under all cereals in most of the States. The first four states-Karnataka, Maharashtra, Rajasthan and Gujarat with predominantly dry farming areas, accounted for 56%, 37% and 41% of the all India area under coarse cereals, pulses and oil seeds respectively (See Table 2.8). The ratio of pulse area to coarse cereal area, however, increased with the rise in rainfall or irrigation of the region, indicating the higher responsiveness of pulses to moisture levels. For example, the contribution to the all India area and production of pulses is higher than those of coarse cereals in high rainfall areas like Madhya Pradesh, Orissa and Bihar and in the States with higher irrigation ratios like Uttar Pradesh or Haryana. The two southern states viz. Andhra Pradesh and Tamil Nadu are, however, exceptions indicating the importance of other factors like suitability of soils.

Regional specialisation is greater in the case of oilseeds. For instance, the five southern and western states viz., Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat and Maharashtra accounted for 85% of all India area under groundnut. The share of Gujarat alone was 29%, while they are 13 and 21% in the case of Tamil Nadu and Andhra Pradesh. As much as 46% of the nation's area under rape and mustard is in Uttar Pradesh and 17% in Rajasthan. Relatively higher percent of the area under this crop is irrigated compared to that under groundnut.

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Table 2.8 States' shares in all India area and production of coarse cereals, pulses and oilseeds (average 1981-84)

States	Coarse cereals		Pulses		Oilseeds	
	Area	Production	Area	Production	Area	Production
<u>Group A</u>						
1. Karnataka	10.6	12.6	6.6	4.8	7.9	7.6
2. Maharashtra	21.1	19.1	11.8	9.1	11.5	10.7
3. Gujarat	6.9	8.1	3.1	3.8	14.2	19.4
4. Rajasthan	17.3	11.0	15.6	13.2	7.5	6.4
Total	56.0	50.7	37.2	30.9	41.2	44.1
<u>Group B</u>						
5. Madhya Pradesh	11.4	10.5	21.4	21.6	12.0	8.5
6. Andhra Pradesh	8.9	9.0	6.2	4.4	11.2	13.2
Total	20.3	19.5	27.6	26.0	23.2	21.7
<u>Group C</u>						
7. Uttar Pradesh	9.4	11.0	12.6	20.2	17.1	12.3
8. Haryana	2.7	2.4	3.4	2.8	1.1	1.2
9. Tamil Nadu	3.7	4.6	2.8	1.8	6.4	9.6
Total	15.7	17.9	18.9	24.9	24.6	23.1
<u>Group D</u>						
10. Bihar	2.9	3.6	5.2	6.0	0.3	1.0
11. Orissa	1.6	1.8	7.3	8.1	4.6	5.4
12. West Bengal	0.3	0.3	1.7	1.9	1.9	1.5
Total	4.8	5.7	14.7	16.0	7.9	7.9
All India	100.0	100.0	100.0	100.0	100.0	100.0

Source: India, Ministry of Agriculture, Directorate of Econ. & Stat., Area and production of principal crops in India, 1981-84.

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Yield levels of the above crops are generally influenced by rainfall, irrigation and suitability of soils, among other factors. The yields of coarse cereals, for example, are higher in the States like Tamil Nadu, Karnataka, and Bihar which have better soils, higher rainfall and/or a greater proportion of the coarse cereals are under irrigation (Table 2.9). Yields are comparatively lower in the low rainfall areas like Rajasthan and Haryana and low irrigation states like Madhya Pradesh. States such as Karnataka and Gujarat, in spite of large proportions of areas under low rainfall (less than 750 mm), have been able to achieve fairly high levels of yields, through better coverage of area under coarse cereals with HYVs and other inputs.

/rainfall
or

Yields of pulses are quite high in northern and eastern states with higher irrigation facilities such as Uttar Pradesh, Haryana, Bihar and Orissa. However, they are lower in the southern and western states even though some of them have good irrigation. In the case of groundnut, Orissa, Gujarat, Andhra Pradesh and Tamil Nadu have achieved high levels of yield. In regard to rape and mustard, Rajasthan and Madhya Pradesh show comparatively better yields. The yields of sesamum are good in the eastern states of Orissa and West Bengal.

3. Soil constraints:

The moisture availability in the soil depends not only on the amount and distribution of rainfall and irrigation but

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Table 2.9
Average yields of coarse cereals, pulses and oilseeds
in India

State	Yields kg/ha. of		
	Coarse cereals	Pulses	Oilseeds
<u>Group A</u>			
1. Karnataka	885	377	607
2. Maharashtra	675	393	588
3. Gujarat	868	631	858
4. Rajasthan	471	434	533
Average	676	427	675
<u>Group B</u>			
5. Madhya Pradesh	687	517	448
6. Andhra Pradesh	755	367	742
Average	717	484	590
<u>Group C</u>			
7. Uttar Pradesh	876	823	453
8. Haryana	666	429	725
9. Tamil Nadu	921	326	942
Average	851	677	593
<u>Group D</u>			
10. Bihar	910	598	486
11. Orissa	835	571	727
12. West Bengal	987	570	502
Average	889	581	632
All India	746	514	631

Source: As for Table 8.

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also on the soil characteristics, especially its depth, water-holding capacity and the rate of infiltration.

The major soil groups occurring in the dry farming areas are (i) red soils, (ii) black soils, (iii) alluvial soils, (iv) sierozemic soils and (v) submontane soils. The distribution of the soil groups among the various States are as follows:-

<u>Sl.No.</u>	<u>Major soil groups</u>	<u>States</u>
1.	Forest and hill, brown mountain meadow and submontane soils.	Jammu & Kashmir, Himachal Pradesh, parts of Uttar Pradesh.
2.	Alluviums and red soils	North West India, West Bengal, Assam.
3.	Alluviums	Punjab, U.P., Bihar.
4.	Red, mixed, black soils and coastal alluviums	Eastern Madhya Pradesh, Orissa Andhra Pradesh.
5.	Alluvium, sierozam and black soils.	Haryana, Rajasthan, Gujarat
6.	Black and red soils	Maharashtra, Western Madhya Pradesh
7.	Red and coastal black soils	Karnataka, Tamil Nadu

The main constraints associated with the above soil groups are the following:-

Surface crusting is a serious problem affecting most of the red, alluvial and sierozemic soil regions constituting eastern and Bundelkhand regions of U.P., submontane region of

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Punjab, Dantiwada region of Gujarat, Western region of Rajasthan, the south western zone of Haryana, southern Karnataka, the Telengana and Rayalseema areas of Andhra Pradesh, uplands of Bihar and Orissa. The soils (light sandy loams and loamy sands) tend to develop crust on the surface with a beating rain. In the off-season also, soil crusting occurs, as the temperature rises. In both the situations, with subsequent rains, water intake is reduced and run off is increased, causing erosion of soil. If crusting occurs after sowing, it hampers seedling emergence leading to poor plant stands. The low moisture retention capacity of these soils is a serious constraint to yields and makes it difficult to develop a suitable technology.

The Field Manual on Dryland Agriculture suggests several methods to tackle the crusting problem. They include: (i) continuous incorporation of a portion of crop residues or stubbles into the soil, (ii) set line cultivation, (iii) ridging, (iv) harrowing and (v) soil mulching. We do not have information about the spread of these practices among farmers except perhaps set line cultivation which is said to be prevalent in Saurashtra. Research evidence suggests that stubble or soil mulching does not have significant effect on crop production during the rainy season. However, it increases the yields of post-rainy season crops, by conservation of moisture. Further, operations like ridging and harrowing require the use of special implements which the small farmers cannot afford to buy, unless they are heavily subsidised.

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Soil erosion caused by runoff water or winds, is a chronic problem of undulating terrain in the dry farming regions, defying a solution in spite of soil conservation efforts spanning over several decades. The soil conservation programmes are, of course, technically sound but administratively or organisationally difficult to implement. The several obstacles encountered in the programmes are :- (i) They involve heavy capital investment in which the farmers, with their poor resource position, are unable to share.

(ii) The construction of soil conservation structures involves cooperative community effort. Often the farmers are not in a position even to contribute their share of labour, either because of competing operations on their own farms or lack of appreciation of the long term benefits of such structures. Their immediate impact on yields is often minimal. Since the benefits of these projects accrue to the community as a whole across space as well as time, it is but appropriate that part of the initial investments are made by the State.

(iii) A more intractable problem is that it is difficult to follow the individual farm boundaries in the construction of bunds and other soil conservation structures. Cutting across farm boundaries does not find acceptance among farmers. If ownership boundaries are followed in this regard, the works do not fully serve their purpose. The proper maintenance of such works is also a problem.

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If crusting is a common problem of red sandy soils, cracking is the feature of heavy black soils occurring in Malva plateau in Madhya Pradesh, Deccan plateau in Maharashtra and Karnataka and the southern region of Tamil Nadu. Cracking develops in the soil from late November onwards, depending on the cessation of rainfall. This results in rapid loss of moisture affecting crop yields. Two ways are suggested to tackle this problems: (i) soil mulching to fill the cracks at early stages and (ii) selection of short duration varieties which complete the dough stage before cracks develop and so will not be affected by them. Mulching, however has its limitation as noted above. It is more useful in the rabi than in the kharif season.

As compared with red soils, deep black soils have better water holding capacity because of their high clay content and so are more productive than the former. The available technology also appears to be more successful on these soils because of its complementarity with the soil moisture levels. However, one limitation of these soils is the low rate of infiltration so that water does not enter the soil even if held for long. This creates either the problem of stagnation in the case of heavy rains or evaporation if it is light. A good part of rainfall is also lost through runoff, so that only a small portion is left as residual soil moisture to grow crops in the rabi season. This limits

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the impact of technology on crop production in rabi. Kharif cropping is suggested as an alternative to rabi cropping but in the heavy black soil regions it is impossible to work the plough in the rainy season with the available bullock power esp. under water logged conditions. This will be possible only under better soil and water management conditions.

Several methods have been successfully tried in experimental centres to increase the rate of water intake in heavy black soils. Off season shallow tillage has been found useful, particularly in years of sub-normal rainfall. Surface mulches are effective in conserving moisture for rabi crops. Land treatments like beds and furrows or flat sowing on grade have also been useful in raising yields. Addition of gypsum has increased the water intake rate by 4 to 7 times at Bellary. Vertical mulching has proved beneficial at Sholapur and Bellary Centres. Deep tillage has been found helpful in some centres in raising moisture storage in soils. Some of the soil and water conservation measures have been successfully tested in farmers' fields through operational research trials conducted at Bangalore Hyderabad, Indore and Hoshiarpur. The measures include contour cultivation, graded bunding, ridge and furrow system, mulching, etc., which have been found particularly useful in raising yields during low rainfall years.

Another major constraint to dryland production is the low nutrient status of the soils which is aggravated over time by soil erosion and runoff. The soils are universally poor in nitrogen and often also in phosphorous. Potassium levels are

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generally satisfactory except in very light soils. So adding sufficient quantities of nitrogen and phosphorous becomes essential for stepping up the yields of dryland crops. Fertiliser use efficiency however depends on the availability of moisture in the soil which becomes critical in poor rainfall years. So there is the risk of loss on fertiliser investment in bad years. Some methods which can reduce this risk are use of moderate levels of fertiliser, placement of fertiliser in the moisture zone of the soil, split application keeping the second dose optional, depending on the moisture availability (so that it can be dropped in bad years) and adoption of complementary cultural practices mentioned above, to conserve the moisture.

We find that the current levels of fertiliser use are very low (often less than 10 kg per ha.) on drylands, even in good rainfall years and still less in bad years. Available evidence suggests that this may be not only due to low return and high risk, but also due to the resource constraints of the majority of dryland farmers who have little access to cheaper institutional credit. The farmers who have partially irrigated holdings tend to divert a large part of the available fertiliser to the irrigated crops because of higher and more certain pay-off and next, to commercial crops under dryland conditions because of higher return on them. The result is a gross under-investment in fertiliser use on drylands, relative to the expected profit maximising levels or optimal levels even under risk-aversion

conditions. Besides resource and credit constraints, inadequate supply outlets for fertiliser and transport difficulties in the dry farming regions may also be responsible for the low fertiliser consumption.

4. Risk, Return and Farmers' Behaviour

The unpredictable weather factors mentioned above introduce a big element of risk and uncertainty in dryland agriculture, in the absence of the stabilising influence of irrigation. Good, average and drought years of varying intensity occur in unpredictable sequence and affect agricultural production as well as the economy as a whole. The Sixth Five Year Plan points out, for instance, that out of a total of 35 rainfall divisions, the number of rainfall divisions with one or more moisture-deficient years in five year periods, was 14 during 1951-55, 13 during 1956-60, 20 in 1961-65, 24 in 1966-70 and 30 in 1970-76. This shows, indeed, an alarming rate of increase, over time, in the extent of areas affected by drought. Causes for this trend need to be investigated so as to assess the relative contributions of natural/suitable policy measures to counteract it. Data show that drought occurs at least once in 3 to 5 years in most of the divisions in the country. While in regions like Madhya Pradesh, Coastal Andhra Pradesh and Maharashtra, drought occurs once in 5 years, in regions like Gujarat, Rajasthan, Tamil Nadu, Rayalseema and Telengana, it occurs once in 3 years.

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It is the drought risks that mainly account for the yield risks in dryland farming. Yield fluctuations in turn lead to price fluctuations- gluts causing steep fall in prices and scarcities resulting in high prices. For instance, the glut in bajra production in Haryana during kharif 1983 led to a steep fall in the market price of bajra (by around 50%) and the Food Corporation of India had to step in to market the surplus at a higher support price.

One main question that we have to consider in dry farming is whether the risk factor retards the adoption of the improved technology by farmers and, if so, what are its implications for public policy. Answer to this question depends mainly on two factors:

- (i) The degree of riskiness of improved practices vis-a-vis the traditional; and
- (ii) The degree of risk aversion of dryland farmers.

Evidence on (i) above indicates that the seed fertiliser-based packages of practices at the recommended levels of inputs are, by and large, more risky than the local practices under dry farming and drought-prone conditions, though they are not more risky under assured irrigated conditions. This is essentially because of the complementarity of moisture levels (in terms of rainfall and/or irrigation) with new seeds and fertiliser. Even if some of the new varieties yield more than the local ones in bad years, the additional yields are smaller

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than in good years and rarely sufficient to recover the costs of additional inputs.

Yield risks as measured by variability seem to be greater for HYVs than for the local varieties and for higher levels of fertiliser than for lower levels. However, higher risks are associated with higher returns so that a trade off is involved between the two.

The results of two studies given in Tables 2.10, 2.11 and 2.12 provide support to the above point. The study by Barah et al based on data from all India coordinated trials for sorghum shows that sorghum hybrids gave higher mean yields than the local and other improved varieties but at the same time, the variability of yields of the former (over time) was also greater. However, the rates of trade off between additional means and standard deviations of the yields of the hybrids were high enough to make the majority of risk averse farmers prefer them to the other varieties. As Table 10 shows, there is very little difference between yield-based ranking and risk preference-based ranking of sorghum genotypes. The most preferred genotype (CSH-5) is also the highest yielder.

The study by Rangaswamy based on data from AICRPDA trials on fertiliser application to cotton at Kovilpatti, also indicates rise in both mean profits and standard deviations as fertiliser dose is increased upto 60 kg N per hectare. However, the difference between profit-maximising (risk-neutral)

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Table 2.10

Ranking of sorghum genotypes according to mean yield and risk preference

Genotype (1)	4 years average yield (q/ha) (2)	Standard deviation (3)	Ranking	
			Yield	Risk pre- ference (4)
CSH - 5	46.80	17.60	1	1
CSH - 4	35.18	13.07	2	2
CSH - 6	35.16	14.64	3	3
CSH - 1	30.29	14.95	4	4
CSH - 2	29.54	15.34	5	5
Swarna	28.12	13.90	6	6
302	24.18	14.27	7	9
148	23.77	11.40	8	7
604	23.09	10.83	9	8
555	21.51	9.48	10	10
Local	18.52	11.74	11	11

Source: B.C.Baranet al, The use of risk aversion in plant breeding; concept and application, ICRISAT, Hyderabad, 1980.

Table 2.11

Return and risk in fertiliser application to rainfed cotton, Kovilpatti.

Nitrogen levels kg/ha	Average net return Rs./ha (M)	Standard deviation (S)	Trade off (S M/ S)	Percent of farmers
0	965	1199	-	66.1
10	1074	1265	1.65	5.6
20	1164	1331	1.36	11.7
30	1235	1392	1.16	10.5
40	1288	1448	0.95	3.7
50	1322	1499	0.67	2.5
60	1337	1547	0.31	-
70	1333	1592	-	-
80	1311	1638	-	-
90	1270	-	-	-

Source : P. Ranga swamy, Risk aversion and Investment gap, Indian Economic Review, Vol. 17, Nos. 2-4, 1982

Table 2.11 Caps in fertiliser investment, yield and net return

	Risk neutral optima	Risks aver- sion optima	Aver. level on farms	Total gap	Gap due to Risk aver sion	Other factors
Fertiliser (kg/ha)	60	50	7	53 (100)	10 (19)	43 (81)
Yield (kg/ha)	409	397	286	123 (100)	12 (10)	111 (90)
Net return Rs./ha)	1337	1322	1029	308 (100)	15 (5)	293 (95)

Source : As for Table 11.

dose of fertiliser(60 kg per ha) and the preferred dose of risk averse farmers(50 kg per ha) was only 10 kg per ha. The actual dose applied was only 7 kg per ha. So, of the total fertiliser investment gap of 53 kg per ha(60-7), only 10 kg or 19% can be attributed to risk aversion, while 81% should be due to other factors including credit constraints,difficulty of access to inputs etc. There is also evidence of rejection of many recommended varieties by farmers in dry land areas. Causes of such rejection have to be carefully probed into. It is possible that the recommended varieties are not necessarily the best among the available ones i.e. those used in the breeding trials. All high yielding varieties may not equally be risk efficient and some may be more risky than others. So a careful screening of the new varieties not only in terms of their mean yields and profits but also their variability at different levels of the associated inputs like fertiliser and their performance particularly in severe and ^{mild} drought years is necessary so that those which offer the most favourable trade-off are released for farmers use.

III

Suggested Strategies for Dryland Agriculture

The basic problems faced by the dryland farmers are poor resource base, moisture scarcity and uncertainty, leading to unemployment and low and uncertain incomes. A multi-pronged attack is necessary to tackle these problems. Public investment and intervention on a scale comparable to that in irrigated areas are called for so that not only regional imbalances can be reduced but also a more broad-based growth strategy may be evolved.

The main elements of such a strategy are:-

1. Effective technology transfer,
2. Strengthening of dryland research,
3. Appropriate policies for credit, subsidies and prices,
4. Infrastructure development,
5. Efficient input delivery system.

1. Technology Transfer:

The immediate need is an effective transfer of the available technology to the farmers' fields. It is nearly fifteen years since the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) and the Integrated Dryland Agriculture Development Project (IDADP) were launched in 24 locations all over India. Location-specific packages of practices have been evolved in the Research Centres and disseminated in the adjoining development project areas. The International Crops Research Institute for semi-arid Tropics (ICRISAT) at Hyderabad has also designed techniques for lower.

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bajra, gram, arhar and groundnut specially suited to deep vertisols with reliable rainfall (above 750 mm). These new techniques appear to have made an impact in many of the project areas but their diffusion outside is not known; it may not be much. As a first step towards wider diffusion, it is necessary to conduct on-farm verification trials and demonstrations within the same or similar agro-climatic zones.

Demonstrations:

Demonstrations are the chief means of convincing and educating the farmers about the improved practices. In IDADP areas, demonstrations are usually conducted at two levels of modern inputs:-

- (i) at zero levels in the control plots using only traditional inputs and
- (ii) at recommended levels in the demonstration plots.

These are somewhat unrealistic because the farmers may be already using some inputs like fertiliser and/or pesticides for some crops. Secondly, the recommended doses also are often found to be quite high, possibly intended to maximise the yields. But the farmer is normally interested in maximising profits, or utility if he is a risk-averter. So a better idea would be to apply farmers' own inputs and input levels in the control plots and new inputs at two levels in the demonstration plots: (i) high level which will maximise expected

or average profits over time and (ii) an intermediate level which most of the farmers with their present resources (owned and borrowed) can afford. The intermediate level may also suit farmers with risk aversion, even if they may not have resource constraints. The farmers can see for themselves by how much they can raise their current yields and profits by adopting the particular input packages.

Besides the demonstrations, other extension methods like training camps, farm visits, group discussions, exhibitions, films and other audio-visual aids need to be extensively and judiciously used so as to quicken the process of adoption. The extension officials themselves—mainly the village level workers—should be given periodical training in the new techniques and programmes. The T & V system with its vertical integration, focus on agricultural programmes and a professional approach seems to be well equipped for this purpose.

Technology components:

Variety: Of the several components of the improved dry farming technology, the variety or genotype is probably the basic. It is generally a low cost input (with some exceptions) compared to fertiliser or pesticides. So the adoption rates for the former are observed to be usually higher than those for the latter in areas where higher profitability of new varieties compared to the local ones is well-established. This implies

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---that many farmers are using the new varieties at zero or very low levels of chemical inputs. This could be attributed not only to resource or credit constraints but also to the riskiness of investment. However, there are several constraints to the widespread adoption of new varieties. The most important of them are possibly their susceptibility to pests and diseases as well as drought conditions. The lack of ready and timely availability of seeds is also a factor limiting their coverage. While the development of disease-free and drought-tolerant varieties should receive high priority in research, great care needs to be bestowed on the selection and release of genotypes from the on-going breeding trials for farmers' use. High average yield cannot be the sole criterion, even though it is quite important. Weightage should be given also to other criteria such as their performance in years of droughts and floods, resistance to diseases, fodder yields and response to low to moderate doses of fertiliser, as compared to the local varieties. These are of obvious importance to the dryland farmers and can influence their adoption rates significantly.

Fertilisers:

The causes for the current low levels of fertiliser consumption in the dry farming areas are low and uncertain rainfall, the riskiness of the hybrid varieties, the high fertiliser-product price ratios, lack of institutional credit, inadequate sale outlets etc. Available evidence suggests

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constraints mentioned above:-

gross under-investments in fertiliser for the dryland crops, in the sense that there is a wide gap between the expected profit maximising doses and the average doses used on the farms. So there is good potential for raising the yields of the rainfed crops by increasing fertiliser consumption. In fact, states like Gujarat have already achieved higher levels of fertiliser consumption leading to a rise in the yields of several dryland crops. Fertiliser consumption can be increased only by removing the/

(i) Any attempt to raise or conserve the moisture levels in the dryland areas is bound to result in more fertiliser absorption not only directly i.e. in the areas already covered by the HYVs, but also indirectly via inducing more area coverage under HYVs which are more responsive to fertiliser. Thus the development of groundwater resources, harvesting of run-off water in community ponds, tanks, etc., will be of great help in this regard. Farm-level agronomic practices like off-season tillage, soil and stubble-mulching, interculturing, harrowing, in situ water harvesting etc., will also help in moisture conservation and thereby the fertiliser use efficiency.

The Integrated Watershed Development Programme initiated in the Sixth Plan and to be intensified in the Seventh Plan will be the first major step to harvest run-off water in ponds and utilise them for critical irrigation. Successful execution and maintenance of these works will go a long way in the absorption of more modern inputs, raising the profitability of dryland crops

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and also reducing the risk of crop losses due to long drought spells in the rainy season.

ii) Other methods to reduce risks and economimising on the use of chemical fertilisers are:-

- a) split application(basal + top dressing) keeping the top dose optimal so that it can be avoided in bad years,
- b) supplementing it with cheaper nutrients like FYM and bio-fertilisers.
- c) inter-cropping of cereals with legumes which can fix nitrogen in the soil;and
- d) development of fertiliser responsive HTVs which are also tolerant of, or resistant to pests and droughts.

iii) Lack of knowledge about the types of fertilisers to be used and methods of their application also appear to be a cause of non-use or wrong use of fertiliser resulting in wastage.

Hence farmers need to be educated in this regerd through fertiliser demonstration trials, radio discussions and other methods. Fertiliser recommendations should be based on soil tests as well as economic principles mentioned above.

Pest control:

Like fertiliser, plant protection chemicals also are costly inputs in relation to the low value of many dryland crops and so farmers do not invest much in them except in the case of high value crops like cotton or groundnut. As su ch, ways have to be

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found to cut down costs on pesticides. Seed treatment with chemicals has often been found to be a simple and cheap means of preventing pest attacks in the case of several crops and so this practice needs to be effectively promoted. Early sowing can help in the avoidance of pests e.g. shoot fly in the case of sorghum, ergot in regard to hybrid bajra. Evolving pest-resistant varieties will also cut down costs on pesticides.

Farmers have to be taught the use of right chemicals in optimal quantities and by proper methods. Group control of pests and diseases can, often, be more effective than individual control and in this respect compact area programmes will be helpful.

Agronomic practices:

There are several other improved agronomic practices - labour intensive, low-cost inputs- which have proved their worth not only in Research Centres but also in Operational Research Trials and demonstrations on farms. Some of them were mentioned above. Among them early sowing of rainy season crops like sorghum, rice, pigeon pea, castor, etc., has been observed to raise their yields by 50 to 100%. Besides escaping insect damage, such crops are also saved from droughts in case of early cessation of monsoon rains.

Practices like off-season tillage, interculture, weeding, maintenance of optimum plant population, proper inter-row and intra-row spacing, etc., also have significant positive

impact on yields. They positively interact with the modern bio-chemical inputs making the package effect greater than the contributions of individual components.

Mid-season corrections:

The AICRPDA has devised some strategies to deal with weather aberrations: (i) Alternative crops and varieties for normal and delayed monsoons have been evolved e.g. sorghum for normal onset of monsoon and sorghum fodder for late onset, in Bellary; rice and transplanted finger millet for the two situations, in Chotanagpur. (ii) If moisture stress occurs immediately after seeding, it is better to resow with subsequent rains. (iii) If dry spell occurs in the later stages of crop growth, other methods like thinning of plant population or retooling can be adopted.

If farmers were to change crops or varieties in the mid-season, it is necessary that the seed supply agencies keep adequate stocks of seeds of alternative crops and varieties.

The above are the important components of the technology designed by AICRPDA. The technology developed by ICRI SAT is specially suited to deep vertisols with dependable rainfall and is similar in several respects to that of AICRPDA. The technology is carried out in small water-sheds ranging from 5 to 25 hectares.

The basic elements of the ICRI SAT package are:-

- i) Post-harvest cultivation after the rabi crop

- ii) Land levelling and shaping, construction of field and community drains and the use of graded broad-beds and furrows;
- iii) Dry seeding before the monsoon;
- iv) Use of improved varieties and moderate amounts of fertiliser;
- v) Proper placement of seeds and fertiliser;
- vi) Timely plant protection

Most of the above practices are carried out with the help of a bullock-drawn wheeled tool-carrier. These practices have been found to be generally profitable in deep vertisols except in drought years. The broad-bed and furrow system facilitates drainage, but where drainage is not a problem, this method has no advantage over flat sowing. The wheeled tool-carrier is too expensive (around Rs.10,000) for an average farmer. It also requires heavy draft animals which the small farmers cannot afford. In the absence of summer showers, preparatory cultivation and dry seeding have been found difficult.

2. Priorities in dryland research:

The above account on the technology transfer reveals the complexities and constraints in evolving a viable and acceptable dry farming technology. Since the soil, weather and other environmental conditions differ from area to area, there is need to design techniques adapted to the specific

agro-climatic conditions of each area. This is not to suggest that the techniques for each area will totally differ from those for other areas. Certainly there are common elements to the extent there are common conditions. Moreover there are certain components of the technology (like some of the hybrid varieties of jowar and bajra) which are adapted to a wide variety of conditions. In fertiliser also, only some minor changes in dose or method of application may be involved. The same applies more or less to other inputs or practices. It is these aspects which have to be looked into in the Adaptive Research Trials to be followed by on-farm Operational Research Trials.

The techniques developed so far by AICRPDA and ICRIAT seem to be suited for the medium and high rainfall areas. A serious gap is the technology for low rainfall areas (below 750 mm). Further, the techniques are found to be more profitable in the deep to medium deep black soil areas than in the red soil or shallow black soil areas for reasons mentioned earlier. For areas with shallow red or black soils (which are not very productive) and with low rainfall, suitable crop techniques have to be evolved. Further, priority should be given to the strengthening of other supplementary enterprises like dairy, agro-forestry, sylvi-pasture etc. in these areas, as crop production alone will not be sufficient for the farmers' sustenance.

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Other gaps in research were also indicated above.

Since seed is the basic component of the technology, the focus should be on the development of varieties with built-in features like resistance to disease as well as moisture stress, short-duration, good response to low-to-moderate doses of fertiliser etc. It may perhaps be easier to manipulate the sowing time and duration of varieties in such a way that the water-sensitive stages of crop growth do not coincide with the dry spells most probable or frequent in the region. Some progress has already been made in these directions.

It will be difficult, of course, to incorporate all the desirable features in one variety of a crop. A trade-off will, certainly be involved between the several traits as, for instance, between drought-resistance and yield, fodder and grain yields, etc. This problem can be resolved by assigning suitable weightage to the different traits in accordance with the farmers' preferences and by offering a choice of varieties with different characteristics. A continuous interaction between the extension and research agencies is essential so that the latter may be alive to the field needs and problems and the former can be familiar with the latest findings of research.

A workshop on Watershed-based Dryland Farming in Black and Red soils of peninsular India held at ICRISAT in 1983 under the Co-sponsorship of NABARD, ICAR and ICRISAT has made the

following recommendations regarding further research needed on dryland farming:-

- i) Analysis of water harvesting and supplementary irrigation which will ensure establishment of the post-rainy season crop in double cropping systems, may be taken up.
- ii) Further research is needed for developing dryland farming in environments with low and undependable rainfall.
- iii) Studies for improving the efficiency of applied nutrients particularly nitrogen in dryland farming require special attention.
- iv) Results from trials carried out in farmers' fields suggest the need for:
 - a) adaptive research on alternative land use systems to ensure technology packages tailored to regional needs;
 - b) Cheaper alternatives to available models of the farm machines, which could suit the animal draft power available locally;
 - c) Modifications in the broad-bed-and-furrow system for higher rainfall environments and for different farming situations;
 - d) Steps in technology experiments to measure the benefits from specific components of the package.

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There is a clear need to strengthen and expand the activities of the Dry Farming Research Centres set up under AICRPDA. More Adaptive Research Centres for coarse cereals, pulses and oil seeds have to be set up. Highly motivated and qualified staff have to be appointed with the assurance of regular promotional avenues. Frequent transfers of staff should be scrupulously avoided since they have seriously affected the continuity of work in the centres.

More funds will be required for the above purposes. The resources now devoted to dryland research are grossly incommensurate with the share of dryland area to total area or the share of dryland production to total production. For instance, Jodha (1983) provides evidence to show that only 18% of the total research expenditure during 1969-70 was allocated to Institutes primarily concerned with dry farming areas/crops, whereas the share of dryland crops in gross cropped area was 37% (See Table 3.1). On the other hand, the lion's share of budget allocation (51%) went to rice and wheat and wet areas, though their share in gross cropped area was only 33%. More or less the same ratios are observed with regard to research institutes or research workers. Another indicator (not shown in the table) is the All India coordinated Agronomic Trials (1976-77), of which 41% related to rice and 46%, to wheat, while sorghum and pearl millet had a meagre share of 4% each.

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The above facts underline the need for a substantial step up in the allocation of funds for dryland research so as to achieve a technological break through.

Table 3.1: Distribution of agricultural research resource allocation for dry farming and other areas/crops

----- % share of research institutes with primary focus on -----					
	Dry farming area/crops	Rice & Wheat & wet areas	Cotton, Jute S. cane & tobacco	Vege tables & fruit ts	Total
Research insti- tutes/stations	15.2	42.5	22.9	19.4	100.0 (642)
Research workers	17.4	46.7	20.5	15.4	100.0 (4058)
Budget allocation	18.1	50.9	20.3	10.7	100.0 (52270,000 Rs.)
Crops share in gross cropped area(1969-70)	37.4	33.2	6.6		

Source: N.S.Jodha, 'Dry Farming Research Issues and Approaches', paper presented at ISAE/ICRISAT/AICRPDA Workshop on Technology Options & Economic Policy for Dryland Agriculture, ICRISAT, Hyderabad, 1983.

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3. Credit, subsidies and prices:

If the above technology is to be widely adopted by the farmers, a majority of whom have small and marginal holdings, it is imperative that they are provided with adequate credit and other financial support. At present, the supply of institutional credit for agriculture is low in the states with large dry farming areas. As Table 3.2 shows, the short-term cooperative credit per hectare is less than the national average (Rs.136) in 8 out of 12 states. Evidently it would be much lower in the predominantly dry farming regions within each state. The credit supply is quite high in Haryana and Tamil Nadu which have also high irrigation ratio. Next to these two states, it is fairly high in Maharashtra and Gujarat where the Cooperative movement has made a headway.

Table 3.2: Irrigation ratio, credit supply and fertiliser consumption

States	Percent gross cropped area irrigated	short-term cooperative credit per ha, 82-83	Fertiliser consumption kg per ha	GCA per sale point of fertiliser
	1981-82	82-83	1983-84	83-84
Group A				
1. Karnataka	16.0	107	43.4	1435
2. Maharashtra	13.2	169	31.5	2222
3. Gujarat	23.1	137	46.1	1573
4. Rajasthan	20.0	66	11.3	4312
Group B				
5. Madhya Pradesh	11.5	72	14.5	2995
6. Andhra Pradesh	35.9	98	69.6	1403

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Group C

7. Uttar pradesh	46.9	120	66.2	1219
8. Haryana	59.3	470	56.0	1922
9. Tamil Nadu	49.6	217	84.9	467

Group D

10. Bihar	33.7	32	27.4	1714
11. Orissa	22.9	95	11.8	1574
12. West Bengal	23.4	58	49.8	439
All India	29.1	136	43.5	1353

Source:- India, Ministry of Agriculture & Rural Development,
Directorate of Economic and Statistics, Indian Agriculture
in Brief, 1985.

2. Fertiliser Association of India, Fertiliser Statistics,
1984-85.

Now that a technology is available which can increase the returns from dryland farming, it would be worthwhile for the cooperative and commercial banks to raise the credit limits for the dryland crops on the basis of the expected incremental incomes. Viable schemes for groups of farmers in each agro-climatically homogenous region have to be prepared on the basis of the available technology, with the active cooperation of the farmers, extension workers and bank officials. Loan procedures need to be simplified and arrangements made for quick disbursement of loans.

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Short-term loans for current inputs should be given in kind as far as possible. Preferably, arrangement should be made for monitoring and supervision of long-term as well as short-term loans. The repayment schedule should be such that it will coincide with the time of income accruals. In bad years with substantial crop losses, the recovery may be postponed to the subsequent seasons. A credit-linked insurance scheme such as the one introduced recently, will be of great assistance to the farmers as well as the Banks in affording risk cover.

Since most of the inputs like fertilisers, plant protection chemicals, improved implements, etc., are quite costly, their sales should be subsidised so as to provide an incentive to the farmers to adopt the new technology. The Centrally sponsored schemes for water-shed areas as well as areas outside them have in fact, made provision for such subsidies. Subsidies may be preferably given at the source i.e. to the official or recognised input supply agencies, so that there is no misuse.

Price support is essential especially in the context of the new technology. It is generally argued that the kind of price support given to the wet land crops like wheat and rice is not available for the dryland crops viz., coarse cereals, pulses and oilseeds and that is one main reason why the production of the latter is not picking up like the former. There is some

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justification in this argument even though the price incentive alone would not be sufficient to give a boost to the production of any crop.. The main thrust has to come from technological advancement and the price and other incentives have to supplement and strengthen it. Wheat and paddy had both the advantages which helped in raising their production (especially that of wheat) substantially. Dryland crops did not have these advantages so far, to the same extent as wheat and paddy. But now that a dryland technology has been evolved and is going to be further developed and disseminated, assurance of remunerative and minimum support prices is essential to induce and sustain the adoption of the technology. This has become important in view of the following considerations:-

With the adoption of the improved technology, unit costs are expected to come down but this may be true only for good years and (hopefully) for an average of three or four years. This may not be true for bad years with a steep fall in the yields.

The price rises may not be sufficient to cover unit costs in the lean years. On the other hand, in the years of bumper harvests, the prices may be so depressed-this will be more so in the case of crops with low elasticity of demand-that they may or may not cover unit costs plus a fair rate of return on the additional investment, in spite of enhanced yields.

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There is evidence which indicates wider fluctuation in the production of several dryland crops compared to the irrigated crops and these have their corresponding impact on price fluctuations. For instance, the study by Hazell(1982) shows that the coefficients of variation of production and yields of coarse cereals were higher than those of rice and wheat during 1967-68 - 1977-78, even though some of the coarse cereals had lower CVs during the pre-green revolution period: 1954/55-1964-65 (see table 3.3). Of the individual states, cereal production was most risky in three major dry farming states- Gujarat, Maharashtra and Rajasthan which had coefficients of variation above 20% in the latter period(Table 3.4).

Nadkarni(1973) shows that C.V of prices and production of pulses, groundnut and jowar predominately grown on drylands were higher than those of wheat or rice during the period 1951-52 to 1966-67(Table 3.5). The C.V. of prices were greater than those of production in the case of all crops and more so, in regard to rainfed ones. As Hazell argues, even modest variations in production can cause prices to fluctuate significantly, since only around one third of food grain output is being marketed, the rest being retained for consumption.

So an integrated policy to stabilise production, consumption and prices of dryland crops is essential so that farm incomes are stable, food shortages are avoided and better

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Table 3.3: Coefficients of variation of production and yields by crops, All India, 1954/55-1964/65 and 1967/68-1977/78

Crop	C.V. of production			C.V. of yield		
	First period	Second period	%change	First period	Second period	%change
Rice	5.25	7.16	36.4	5.26	5.85	11.2
Wheat	8.45	8.63	2.1	8.31	5.41	- 35.0
Bajra	8.53	27.74	225.2	7.91	23.62	198.6
Barley	11.16	13.60	21.9	8.36	6.41	- 23.4
Jowar	9.91	14.11	42.4	8.92	11.77	32.0
Maize	4.32	11.59	168.3	6.37	10.87	70.6
Ragi	4.12	12.07	193.0	4.04	9.08	124.6
Small millets	9.28	9.33	0.5	6.95	7.47	7.5
Total Cereals	4.03	5.85	45.2	3.70	4.46	20.4

Source: P.B.R.Hazell, Instability in Indian Foodgrain Production, Washington; IFPRI, 1982.

Note: The first period is from 1954/55 to 1964/65, the second period is from 1967/68 to 1977/78.

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Table 3.4: Coefficients of variation of production and yields of total cereals by states, 1954/55 - 1964/65 and 1967/68-1977/78

<u>Group A</u>	<u>C.V. of Production</u>			<u>C.V. of yields</u>		
	<u>First period</u>	<u>Second period</u>	<u>% change</u>	<u>First period</u>	<u>Second period</u>	<u>% change</u>
1. Karnataka	4.65	13.43	188.8	4.70	8.95	90.4
2. Maharashtra	7.82	25.31	223.7	7.30	21.92	200.3
3. Gujarat	15.50	25.25	62.9	13.80	19.90	44.2
4. Rajasthan	9.20	21.86	137.6	7.82	19.51	149.4
Group B						
5. Madhya Pradesh	8.66	8.52	-1.6	8.88	8.23	-7.4
6. Andhra Pradesh	3.72	8.65	132.5	3.53	6.12	73.4
Group C						
7. Uttar Pradesh	7.60	7.52	-1.1	7.07	6.85	-3.1
8. Haryana	6.52	11.06	69.6	5.84	10.53	80.3
9. Tamil Nadu	3.16	14.10	345.8	2.08	9.72	367.3
Group D						
10. Bihar	11.12	8.77	-21.1	9.35	7.35	-21.4
11. Orissa	8.88	12.41	39.8	9.07	11.84	30.7
12. West Bengal	8.54	8.90	4.2	7.02	7.87	12.1
All India	4.03	5.85	45.2	3.70	4.46	20.4

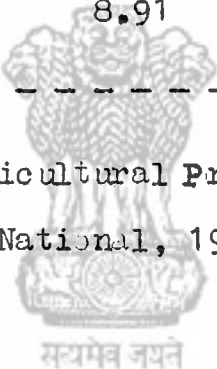
Source: As for Table 3.3

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Table 3.5: Coefficients of variation of prices and production adjusted for trend, India, 1951/52 to 1966/67

Commodity	Prices	Production
Pulses(Group)	20.90	10.39
Gur	19.33	9.44
Groundnut	17.26	11.00
Jowar	16.88	10.49
Wheat	13.59	8.92
Cereals(group.)	11.29	7.22
Rice	8.91	8.83

Source: M.V.Nadkarni, Agricultural Prices and Development with Stability, Delhi National, 1973.



adjustment to droughts and other risks is made possible. Towards this end, procurement and bufferstock operations and public distribution system which are now largely confined to rice and wheat need to be extended to coarse cereals, pulses and oil seeds and to the benefit of both rural and urban areas.

It has been argued by some that the dryland crops are largely subsistence crops with very limited market surplus and hence price support is not essential for them. This is certainly not true of pulses and oil seeds which are mostly grown for the market. As Table 3.6 shows, the proportion of market arrivals to production of gram has been not only consistently higher than that of wheat, but also the proportion of gram arrival has gone up in the latter half of the 70's compared to the early half. The proportion of market arrivals to production of jowar has been lower than those of the other three crops but this proportion has been maintained over the years except for the fluctuations. Moreover, market arrivals of coarse cereals are likely to be higher in predominantly dry districts as compared to other areas and even as compared to other crops in the same area. For instance, Nadkarni (1980) estimates from farm management data that in the typical dry farming district of Ahmednagar in Maharashtra, Jowar accounts for 56% of total food grain production and 43% of the gross marketed surplus of foodgrains. The corresponding shares for wheat are 17% and 21%. So it is essential to provide market and price support to rainfed crops as argued above.

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Table 3.6: Estimated arrivals of rice, jowar, wheat & gram from villages to wholesale assembling markets as percentage of production

Year	Rice	Jowar	Wheat	Gram
1971-72	23.9	11.5	34.8	27.4
1972-73	23.6	14.3	31.2	26.2
1973-74	22.4	10.8	23.4	23.9
1974-75	22.0	8.8	23.9	27.6
1975-76	26.2	11.2	30.5	33.6
1976-77	28.1	12.5	31.7	37.1
1977-78	27.5	12.0	28.6	34.0
1978-79	27.9	9.8	26.8	33.3
1979-80		10.6	31.4	32.6
1980-81			31.9	36.3
1981-82(P)			25.7	

Source: India, Directorate of Economics & Statistics, Ministry of Agriculture, Bulletin on Food Statistics, 1982-84.

4. Market Infrastructure:

It is true that there are several other marketing problems in dryland areas like lack of regulated markets, good transport system, surfaced roads, adequate storage facilities, post harvest technology etc., which greatly impair the marketing efficiency, unduly increase the margins of middle men and reduce the share of the producer in the consumer's rupee. The study by Patnaik.

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(1985) on groundnut marketing in Rayalseema region(A.P.) reveals that among the five marketing channels, the producer's share is lowest in the channel where farmers sell through village merchants in unregulated market and it is highest in the channel where farmers directly sell to cooperative processing units in unregulated market, followed by the channel in which they sell through commission agents in regulated market. Other studies (Patel 1971, Narappanavar and Bharadwaj 1983) indicate an increase in the miller's share and reduction in the farmer's share in the consumers' rupee over time. Studies by Ranade, Singh and Rao (1979) on cotton marketing and by Ranade, Rao and Sah (1982) on groundnut marketing shows that the farmer's share in the final price can be improved by vertical integration of production, processing and marketing through cooperative organisation. It is estimated that the net benefits to growers after vertical integration of groundnut market in A.P will go up by 34% to 114% depending on the channel that is integrated (Table 3.7).

5. Input delivery system:

Ready availability of quality inputs at reasonable prices is a major determinant of the rate of adoption of the improved technology by farmers. Seeds and fertiliser being the main yield increasing inputs, there should be sufficient number of sale outlets for them ensuring easy access to farmers.

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They are not adequate in the dryland areas. For instance, as Table 3.2 indicates, in 9 out of the 12 states with large rainfed areas, fertiliser sale points relative to gross cropped area are less than the national average (or average area covered by each sale point was more than the all India average). One can also observe a positive relationship between the number of sale points and consumption of fertiliser per ha. even though consumption depends also on other factors like irrigation and HYV coverage.

If inputs are readily available in the neighbourhood, the transport and other costs incurred by farmers in their purchases will be minimum. This cost saving is particularly important for dryland farmers in general and small farmers in particular, since their input requirements will be comparatively smaller and additional costs will reduce the profitability of the inputs very much. Public investment and intervention in this regard are quite essential, as the Seventh Plan lays great stress on assistance to the small farmers to raise their output. It is well known that the small farmers often lag behind the big and medium farmers in technology adoption, the main reason for which is the difficulty of farmer's access to credit and inputs.

The overhead and other costs incurred by the Government in this connection as well as other infrastructure development activities mentioned above need to be considered not merely on efficiency grounds but also on equity principle. They will, in

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Table 3.7: Additional benefits to groundnut growers after vertical integration, A.P.

	Private		Cooperative	
	Channel I	Channel V	Channel III	Channel II
<u>Farm level</u>	<u>Rs. per quintal</u>			
i) Growers' net income	72.78	106.17	87.00	42.37
<u>Trade & Industry</u>				
ii) Margin to commission agent	8.03			1.00
iii) Margin to expeller unit	23.37	15.19	15.50	27.87
iv) Margin to solvent extraction unit	8.34	8.71	9.09	8.34
v) Terminal market price	289.99	296.47	303.73	289.99
vi) Net margin to trade & industry(ii)+(iii)+(iv)	39.74	23.90	24.59	37.21
vii) Net benefits to growers (vi)+purchase tax saved	50.98	35.82	36.06	48.24
viii) Percent increase in growers' net income (vii)/(i) x 100	70	34	41	114

Source: C.C.Ramade, K.H.Rao & D.C.Sah, Groundnut Marketing, Ahmedabad, IIM, 1982.

Channel I: Through private commission agents in the regulated market.

II: Through cooperative societies acting as commission agents in the regulated market.

III: Farmers directly selling to cooperative oil mills.

V : Farmers directly selling to private oil mills.

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fact, promote the ends of both growth and social justice.

The production of the inputs including improved implements requires to be stepped up to meet the likely increase in demand. In fact, the supply of inputs like certified seeds is found in several places, to be short of even current demand. This may be more so in the case of hybrid and improved varieties for coarse cereals, pulses and oil seeds, since the infrastructure for seed production and multiplication (breeder, foundation and certified seeds) is still undeveloped for them as compared to that for wheat and paddy. The Government has however, initiated a number of steps to remedy this situation. These steps include greater involvement of the State Seeds Corporations and private producers in seed production, strengthening of seed infrastructure, closer monitoring of the supply position etc. This constraint exists, more or less, for other inputs also. Apart from increasing the production of inputs, it is also crucial to raise their production efficiency so that unit costs can be brought down. Also strict quality control has to be maintained.

Improved implements like the seed-cum-fertiliser drill should be made available on custom-hiring basis since the small farmers cannot afford to purchase them. A new scheme for the establishment of 1200 farmers' agro_Service centres in 600 selected blocks of the country (at the rate of two per block) has been started by the Government of India for this purpose since 1983-84. Most of these centres will be owned by the

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Cooperatives and Panchayat Sanitis. Provision has also been made for demonstrations of these implements in the blocks, particularly in the dry farming areas.

The new strategy for dryland farming:

The strategy for the development of dryland farming based on the watershed approach has been evolved after consultations between the Central and State Governments and agricultural scientists. Under this scheme, selected watersheds are being treated with dry farming practices according to a phased programme. Simultaneously the work is also being carried out in the areas outside the watersheds for promoting the adoption of available techniques like the use of improved seeds, fertiliser, seed-cum-fertiliser drill etc. Out of 4246 micro-water sheds identified in 1982-83, 3967 watersheds were taken up for intensive development during 1983-84. These cover an area of about 3.3 million ha., while 18 million ha outside the watersheds have been benefited by improved dry farming practices.

The watershed approach offers an excellent opportunity for an organised and integrated management of dry lands. It can facilitate an optimal use of the available resources including soils and water. It can lead to greater diversification of dryland farming by promoting animal husbandry, agro-horticulture, sylvo-pastoral system etc. which would generate more employment and income-earning opportunities and also reduce the risks inherent in crop-centred activity.

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The success of this project, however, depends on several factors including close cooperation among the farmers and project officials, coordination of the activities of the several departments, building up of the required infrastructure for the various services and so on. All these cannot be accomplished in the short-run. Hence this will be a phased programme. To begin with, crop enterprises can be taken up for which technology is available. Gradually other programmes may be taken up depending on the local needs, farmers' skills, resource availability, land use capability, infrastructure and marketing facilities, etc. Proper planning of each activity taking into account all the above factors and with the active involvement of the farmers will be crucial for its success. Close coordination between watershed development and poverty alleviation programmes like IRDP, NREP, TRYSEM and RLEGP will be mutually beneficial, since the types of activities covered by them are similar. This will avoid duplication of effort and help in the pooling of resources—both men and materials—for their more effective utilisation.

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